An economical energy storage system leads a representative sampling of aerospace technology applications to energy development, supply and conservation

An Innovation for the Energy Industry

Although the energy crisis of the 1970s has abated, it significantly elevated the cost of energy and thus inspired a continuing quest for better ways of managing energy use. An important part of this quest is finding new and more efficient methods of storing energy. Utility companies, for example, need an economical means of "load leveling"—storing thousands of kilowatts of energy during low demand periods for later use when demand peaks. On a smaller scale, operators of solar electric and wind energy systems must store energy for use at times when sunlight and wind force are not available; storage costs have been a major drawback to widespread employment of such systems, so a low-cost storage technique could hasten their acceptance and substantially increase the national energy supply.

For more than a decade, NASA and the Department of Energy have been investigating a variety of energy storage concepts. One program—called REDOX and developed by Lewis Research Center—advanced to the point where the technology could be transferred to the private sector. Last August, NASA and Standard Oil Company of Ohio (SOHIO) concluded a licensing agreement whereby SOHIO will take over the technology for further development and possible commercialization.

REDOX is a compression of Reduction and Oxidization, a term commonly used in battery technology. The system promises major reductions in the cost of storing electrical energy, long-term reliability and minimal impact on the environment.

The heart of the REDOX system is a series—or "stack"—of flow cells. Chemical energy is converted into electrical energy when two reactant fluids—solutions of chromium chloride and iron chloride—are pumped through the stack. In each flow cell, the fluids are kept apart by a special membrane. Ideally, the membrane prevents reactant ions in one fluid from mixing with reactant ions in the other fluid. However, the membrane allows smaller chlorine and hydrogen ions to pass through freely and transfer electric charge, carrying a flow of electric current through two electrodes.

The electrical energy is withdrawn at external connections to the electrodes. When the electrochemical energy in the fluids is depleted, the system can be recharged by pumping the reactants through the stack again—but with electrical energy supplied by an outside source. The reactants can be used indefinitely. Only a small fraction of the system's energy is consumed in operating the circulating pumps; 75 percent of the energy used to charge the system is returned on discharge, an efficiency comparable to conventional batteries.

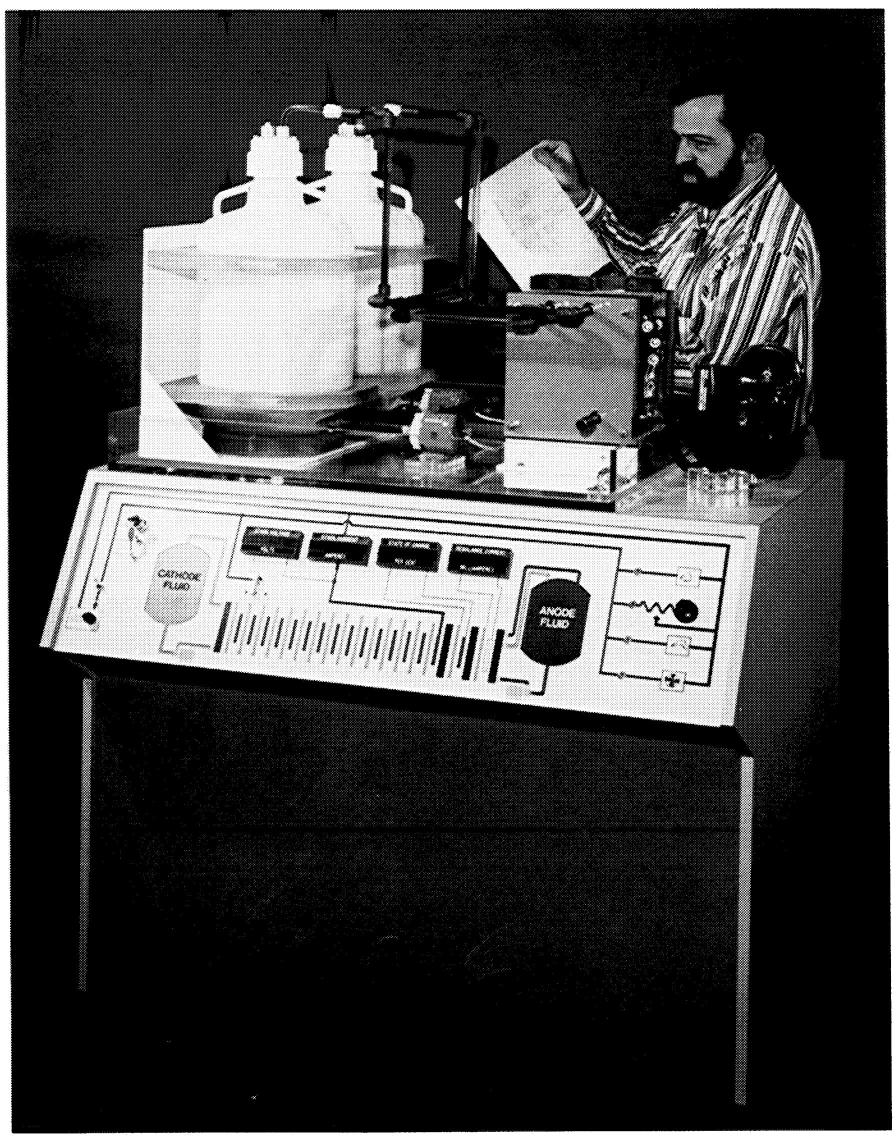
But REDOX offers a number of advantages over conventional batteries. The lead-acid battery in use for more than a century has a major drawback: during recharge, the solid lead compounds on the electrodes do not always return to their previously charged sites and some lead solids fall away from the electrodes. This loss of active material causes gradual battery deterioration and ultimately the battery is useless. In REDOX, no solid compounds are formed, hence there is no deterioration. The life-limiting component is the membrane, whose useful life—based on extensive testing by Lewis Research Center—is estimated at 20 to 30 years.

A major advantage of REDOX is its flexibility: the stack and the storage tanks can be sized independently to yield the best system characteristics for a given application. Stack size depends on the desired power (watts) to be delivered at any one time. Storage tanks are sized for the energy (watt-hours) needed for the time between recharge cycles, which can be days, weeks or even months. This capability for independent sizing means potentially longer storage times, greater energy storage levels and lower storage costs.

Lewis' REDOX system was demonstrated by frequent operation of a portable 200-watt unit. The system can be scaled up to the kilowatt range to the benefit of solar electric and wind energy systems. Fairly small, these systems are usually isolated from utility power lines. REDOX promises a one-to-one replacement of presently-used lead acid batteries at greatly reduced cost—perhaps as low as one-third of current outlays.

Scaled up to the megawatt range, REDOX could effect large savings for utilities by providing an energy reservoir to be called upon during periods of maximum consumption. Economical, efficient REDOX storage could obviate the need for relatively expensive, less efficient standby generating equipment and also eliminate the use of high quality levels for these generators. An energy storage system like REDOX would be of greatest value to utilities that generate power from coal or nuclear energy; such units operate most efficiently at a steady output and they produce the cheapest electricity other than hydroelectric systems. REDOX could also help small metropolitan systems that purchase much of their power at complex rates dependent upon peak demand; by buying power at offpeak rates and storing it, they could realize substantial cost reductions.

Dr. Glenn L. Brown, SOHIO vice president of technology and planning, voiced his company's optimism about the potential of REDOX in comparison with lead-acid battery storage, in particular its longer life and lower construction/maintenance costs. "Although additional basic research and development work will be required," he said, "SOHIO believes this technology may help to reduce America's energy costs at some point in the future."



This is a 200-watt demonstration unit of a unique, NASA-developed energy storage system known as REDOX, which—scaled up to much higher power levels—promises major reductions in the cost of storing electrical energy.